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61. Hiatus Resolution

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Sections

1 Overview of hiatus resolution

The term *vowel hiatus* is commonly used to refer to a sequence of adjacent vowels belonging to separate syllables, as in the following Hawaiian examples from **Senturia (1998**: 26). (Periods indicate syllable boundaries.)

(1)	[ko.a.na]	'space'
	[li.le.a]	(name of a shell)
	[ku.a]	'back'
	[hu.e.lo]	'tail'
	[hu.i.na]	'sum'
	[ko.e.na]	'remainder'

In some languages, vowel hiatus is permitted quite freely. Other languages place much stricter limits on the contexts in which heterosyllabic vowel sequences can occur, while some disallow them entirely. Languages that do not permit vowel hiatus may employ any of several processes that eliminate it in cases where it would otherwise arise (e.g. where an underlying vowel-final morpheme directly precedes a vowel-initial morpheme).

One of the most common forms of hiatus resolution involves the elision of one of the two vowels. (See CHAPTER 68: DELETION.) Vowel elision is illustrated below with examples from Yoruba, adapted from **Pulleyblank (1988)**.

(2)	/bu ata/	→	[ba.ta]	'pour ground pepper'
	/gé olú/	→	[gó.lú]	'cut mushrooms'
	/ta epo/	→	[te.po]	'sell palm oil'
	/kɔ́ ɛ̀kɔ́/	→	[kɛ́.kɔ̌]	'learn'
	/ɾa ɔwɔ̀/	→	[ɾɔ.wɔ̀]	'buy a broom'

In all of these examples, it is the first of the two adjacent vowels (V_1) that deletes. Though this is the more common pattern cross-linguistically, cases in which the second vowel (V_2) deletes are also attested (and indeed, some instances of V_2 deletion are found in Yoruba itself).

In another very common hiatus resolution process, *glide formation*, V_1 is converted to a semivowel (see also CHAPTER 15: GLIDES). One well-known case, illustrated in (3), is Ganda (**Tucker 1962**; **Katamba 1985**; **Clements 1986**).[1]

(3)	/mu-iko/	→	[mwiː.ko]	'trowel'	cf. [mu-leːnzi]	'boy'
	/li-ato/	→	[ljaː.to]	'boats'	cf. [li-ggwa]	'thorn'
	/mu-ezi/	→	[mweː.zi]	'moon'		
	/mu-ogezi/	→	[mwoː.ge.zi]	'talker'		
	/mi-ezi/	→	[mjeː.zi]	'moons'		
	/mu-ana/	→	[mwaː.na]	'child'		

In general (we will look at an exception in §2.4 below), glide formation in Ganda applies only where V_1 is high. Non-high V_1's are elided before another vowel, with compensatory lengthening of V_2 (e.g. /ka-oto/ 'small fireplace' > [koːto]).

A third common pattern, *coalescence*, involves the merger of V_1 and V_2 to form a third vowel that combines features of both. This is illustrated in the Attic Greek examples below (**de Haas 1988**: 126). In these examples, various underlying sequences that combine a non-high [−ATR] vowel /a ϵ ɔ/ with a mid [+ATR] vowel /e o/ are realized phonetically as a long mid [−ATR] vowel that retains the backness and roundness of the original [+ATR] vowel.

(4)	/gene-a/	→	[gé.nɛː]	(/ea/ > [ɛː])	'race (NOM ACC PL)'
	/tiːma-omen/	→	[tiː.mɔ̂ː.men]	(/ao/ > [ɔː])	'honor (1PL PRES IND)'
	/ajdo-a/	→	[aj.dɔ̂ː]	(/oa/ > [ɔː])	'shame (ACC SG)'
	/dɛːlo-ɛːte/	→	[dɛ.lɔ̂ː.te]	(/oɛː/ > [ɔː])	'manifest (2PL PRES SUBJ)'
	/zdɛː-omen/	→	[zdɔ̂ː.men]	(/ɛːo/ > [ɔː])	'live (1PL PRES SUBJ)'

Note that for the pairs /a o/ and /ϵː o/, coalescence in Attic Greek is symmetric; the phonetic result is the same for both orders of input vowels.[2] Other languages with symmetric coalescence include Quebec French, Korean, Rotuman, Old Portuguese, and Classical Sanskrit (all discussed in **de Haas 1988**), and Afar (**Bliese 1981**). Symmetric coalescence is relatively uncommon, however. Much more frequently, coalescence applies only when the vowels occur in one of the two possible orders (see §2.3 below).

Other languages avoid hiatus by retaining both vowels but syllabifying them into the nucleus of a single syllable, a process generally known as *diphthong formation* or *diphthongization*. This occurs in Ngiti, as illustrated in the following examples, adapted from **Kutsch Lojenga (1994**: 90–91).

(5)	/abvo àji/	→	[a.bvoà.ji]	'widow'
	/tìtɔ̀ akpà/	→	[tì.tɔ̀a.kpà]	'liar'
	/opi àji/	→	[o.pià.ji]	'Lendu woman'
	/ìnɖɽì akpà/	→	[ìn.ɖɽìa.kpà]	'male goat'
	/fà ɔ́ɲɔ̀/	→	[fàɔ́.ɲɔ̀]	'our food'
	/fʊ̀kʊ́ oɓi/	→	[fʊ̀.kʊ́ó.ɓi]	'your (PL) knives'

Kutsch Lojenga states that "both vowels must be realised as a short complex vowel nucleus on one V timing slot." She further notes (personal communication) that the first vowel in each sequence is shorter in duration than the second vowel, though not to the point where any auditory distinctions among vowels in V_1 position are neutralized. This argues against an analysis (i.e. glide formation) in which V_1 is syllabified as a consonantal onset.

Other languages that exhibit diphthong formation include Haitian Creole (**Picard 2003**), Indonesian (**Rosenthall 1997**), Attic Greek (**Senturia 1998** and references therein), Obolo (**Faraclas 1982**), Bakossi (**Hedinger and Hedinger 1977**), Eastern Ojibwa (**Howard 1973**), Margi (**Tranel 1992**), and Larike (**Rosenthall 1997**).

Finally, an obvious means of eliminating vowel hiatus is to epenthesize a consonant between the two vowels. One language in which this occurs is Washo, as illustrated in the examples below, adapted from **Midtlyng (2005)**; in each example a semivowel [j] is inserted between the initial vowel of a suffix and the final vowel of a preceding morpheme.

(6) a. 'laːdu-a → ['laː.du.ja] 'in my hand'
'my hand-LOC'
b. le'guʔu-iʔ → [le.'gu.ʔu.ji] 'my daughter's child'
'(1SG OBJ) mother's mother-ATTRIB-AG'
c. 'lemts'iha-i → ['lém.ts'i.ha.ji] 'I am waking him up'
'I cause to awake-IMP'
d. 'lemlu-'eːs-i → ['lém.lu.'jeː.si] 'I am not eating'
'I eat-NEG-IMP'

Though these hiatus resolution strategies have been presented independently using data from different languages, it is common to find two or more different strategies at work in the same language (see §2.5).

It is also common to find that languages tolerate hiatus in some contexts but not others. A number of factors are capable of blocking or influencing hiatus resolution, including the nature of the prosodic or morphosyntactic boundary at which hiatus arises (**Kaisse 1977**; **Baltazani 2006**), prominence factors such as stress (**Senturia 1998**), vowel length and tone (**Casali 1998**: 73), minimal word length or weight conditions, the lexical or functional status of particular morphemes, rate of speech, and sensitivity to particular lexical items. Hiatus resolution also sometimes shows *derived environment effects* (see CHAPTER 88: DERIVED ENVIRONMENT EFFECTS), in which hiatus is tolerated in vowel sequences internal to a morpheme, but is eliminated in cases where two vowels come together across a morpheme boundary. Finally, morphemes consisting of just a single vowel are sometimes resistant to loss through elision, presumably due to the loss of semantic content that could result (**Casali 1997**).

Hiatus resolution can also arise in cases where *three* (or more) underlying vowels occur in sequence. Such cases are considerably less common, and it is difficult to make many strong generalizations about the resolution of /$V_1V_2V_3$/ sequences. Attested outcomes include gliding of V_2 (e.g. Eastern Ojibwa [**Howard 1973**]; Ganda [**Clements 1986**: 75]), and elision of both V_1 and V_2 (Baka [**Parker 1985**]).

The remainder of this paper is organized as follows. In §2, I describe some major respects in which hiatus resolution processes vary across languages. §3 discusses the treatment of hiatus resolution within various theoretical models and some associated challenges and issues. The paper concludes with a brief summary in §4.

2 Typological variation

Hiatus resolution patterns show considerable variation across languages, and any survey of this variation in a work of the present paper's scope will necessarily be selective.[3] Here we will look at certain aspects of variation involving consonant epenthesis (§2.1), vowel elision (§2.2), coalescence (§2.3), and glide formation (§2.4), as well as the co-occurrence of multiple processes within a single language (§2.5).

2.1 Consonant epenthesis

A question that naturally arises in looking at hiatus resolution by consonant epenthesis is *which* consonants can function epenthetically as hiatus interrupters. Three possibilities seem reasonably well attested:

(i) A semivowel, usually one that is homorganic with (i.e. shares the same frontness or roundness as) V_1 or V_2.

(ii) A glottal stop ([ʔ]) or fricative ([h]).

(iii) A coronal consonant, generally [t] or a rhotic.

By far the most common pattern (**Picard 2003**; **Uffmann 2007**) is the first one. This is sometimes explained (see for example **Uffmann 2007**) by assuming that homorganic glide epenthesis is in some sense different from (and less costly than) epenthesis of an entirely new segment, since the glide might be interpreted as a prolongation of phonological content that is already present. However, there are also languages – e.g. Ait Seghrouchen Berber (**Senturia 1998**), Galacian (**Picard 2003**), and Washo (**Midtlyng 2005**) – that consistently epenthesize [j], regardless of the featural content of adjacent vowels, and at least one language, Chamicuro (**Parker 1989**; **de Lacy 2006**), with consistent [w]-epenthesis.

An example of a language with glottal stop epenthesis is Malay (**Ahmad 2001**). The examples below show insertion of a glottal stop between a CV prefix and vowel-initial root:

(7) /di-ubah/ → [diʔubah] 'to change (PASS)'
/sə-indah/ → [səʔindah] 'to be as beautiful as'
/sə-elok/ → [səʔeloʔ] 'to be as pretty as'
/di-olah/ → [diʔolah] 'to beguile (PASS)'
/di-aŋkat/ → [diʔaŋkat] 'to lift (PASS)'

Other languages that epenthesize [ʔ] in at least some hiatus contexts include Ilokano, Selayarese, Tunica, and Indonesian (see **Lombardi 2002** and references therein).

A well-known case of epenthesis of a coronal consonant in hiatus contexts is Axininca Campa (**Payne 1981**; **Lombardi 2002**; **Baković 2003**), illustrated in the examples below (**Payne 1981**):

(8) /i-N-koma-i/ → [iŋkomati] 'he will paddle'
/i-N-koma-aa-i/ → [iŋkomataati] 'he will paddle again'

These examples show an epenthetic [t] interrupting vowel hiatus in suffixal contexts; hiatus in prefixal contexts is resolved in Axininca Campa by eliding one of the vowels instead.

The problem of predicting the range of possible epenthetic consonants has received significant attention in recent theoretical work. This is discussed further in §3.3.3 below.

2.2 Vowel elision

A natural question that arises in connection with vowel elision is *which* of two adjacent vowels elides. Cross-linguistically, elision of V_1 is far more common than elision of V_2 (**Bergman 1968**; **Lamontagne and Rosenthall 1996**; **Casali 1997, 1998)**. Interestingly, it turns out that the contexts in which V_2 elision is well attested are not random. Clear cases of V_2 elision are largely confined to two contexts: (i) the boundary between a lexical (content) word and a following function word, and (ii) stem—suffix boundaries.[4]

Examples of the former type, from Etsako (**Elimelech 1976**), are shown in (9). Note that the latter also display V_1 elision of the final vowel of a *preceding* function word, suggesting rather strongly that it is lexical or non-lexical status, and not simple linear order, that is relevant in this case (see also **CHAPTER 104**: ROOT—AFFIX ASYMMETRIES).

(9)	/ɔna	aru	ɔli/	→	[ɔnaruli]	'that louse'
	the	louse	that			
	/ɔna	eɣi	ɔna/	→	[ɔneɣina]	'this tortoise'
	the	tortoise	this			

Examples of the latter type, adapted from Okpe (**Pulleyblank 1986**), are shown in (10).

(10) /è-sé-ó/ → [èsé] 'to fall'
INF-fall-INF
/ɛ̀-dɛ́-ɔ́/ → [ɛ̀dɛ́] 'to buy'
INF-buy-INF

Compare these forms with the additional Okpe words in (11), where the final V suffix is retained following an underlying high vowel, which undergoes glide formation.

(11) /è-tí-ó/ → [ètjó] 'to pull'
INF-pull-INF
/ɛ̀-sʊ́-ɔ́/ → [ɛ̀swɔ́] 'to sing'
INF-sing-INF

At other kinds of morphosyntactic boundaries, such as that between a prefix and following root or between two content words, elision regularly targets V_1. The cross-linguistically well-attested possibilities are summarized below. (See **Casali 1997** for more discussion.)

(12) *Vowel elision and morphosyntactic position*

Context	*Robustly attested possibilities*
Between two content words	V_1 elision
Content word before function word	V_1 elision or V_2 elision
Prefix + root	V_1 elision
Root + suffix	V_1 elision or V_2 elision

As noted previously, symmetric coalescence, as in the Attic Greek data in (4), is relatively rare. By far the most common form of coalescence is a directionally asymmetric pattern, termed *height coalescence* in **Casali (1998)** (see also **Lamontagne and Rosenthall 1996**; **Parkinson 1996**), in which a non-high V_1 and a high V_2 coalesce to form a non-high vowel otherwise identical to V_2, e.g. /a+i/ > [e], /a+u/ > [o], as in the Xhosa examples below (**Aoki 1974**).

(13) /wa-inkosi/ → [wenkosi] 'of the chiefs'
/wa-umfazi/ → [womfazi] 'of the woman'

The reverse sequences /i+a/ and /u+a/ are not subject to coalescence in Xhosa, but are resolved instead by vowel elision and glide formation, respectively (see §2.5 below).

Languages in which the feature [ATR] is contrastive sometimes show a slightly more elaborate form of asymmetric height coalescence, in which the [ATR] value of a non-high V_1 is preserved in some cases as well. Such languages divide into two types: those in which [−ATR] is systematically preserved (e.g. /a+i/ > [ɛ], /ɛ+o/ > [ɔ]), and those in which [+ATR] is preserved (e.g. /a+i/ > [e], /o+ɪ/ > [e]). Languages of the former type include Owon Afa (**Awobuluyi 1972**) and Anufo (**Adjekum *et al.* 1993**). Languages of the latter type include several North Guang languages and Southern Sotho (**Casali 1998, 2003** and references therein).[5]

Though asymmetric height coalescence most commonly applies to sequences in which V_1 is lower than V_2, cases of "reverse height coalescence" also exist in which a higher V_1 followed by a lower V_2 yields a lowered version of V_1 (e.g. /i +a/ > [e], /u+a/ > [o]), while the opposite sequences do not trigger coalescence. This occurs in Foodo (Kwa; Ghana; **Plunkett 1991**: 68), as shown below. (The initial and final /a/'s are noun class affixes. The tonal changes are due to independent processes discussed in Plunkett.)

(14)	a.	/i+a/	> [eː]	/á-bì-á/	→ [ábêː]	'seeds'	cf. [dí-bí-lì]	'seed'
	b.	/ʊ+a/	> [ɔː]	/á-sʊ́-á/	→ [àsɔ̂ː]	'ears'	cf. [kʊ̀-sʊ́]	'ear'
	c.	/u+a/	> [oː]	/á-jù-á/	→ [ájôː]	'millet'	cf. [dú-jú-lì]	'millet'

Sequences in which V_2 is high and V_1 is non-high do not undergo coalescence; compare the /ʊ+a/ sequence in (14b) with the /a+ʊ/ sequence in /kʊ̀-tá-ʊ́/ 'bow', which is retained in the surface form, [kʊ̀táʊ́].

Other languages with reverse height coalescence patterns include Tem (**Tchagbale 1976**; **de Craene 1986**), Chagga (**Nurse and Philippson 1977**; **Saloné 1980**), Ewe (**Westermann 1930**), Bakossi (**Hedinger and Hedinger 1977**), and Nkengo (**Hulstaert 1970**). Interestingly, such patterns seem to occur predominantly at root-suffix boundaries, a restriction that partly parallels some limitations on the distribution of V_2 elision (§2.2).

A further coalescence pattern that should presumably be expected to occur is one in which front unrounded and back rounded vowels coalesce to form a front rounded vowel, e.g. /i+u/ > [y], /e+o/ > [ø], etc. Patterns of this type appear to be considerably less common than height coalescence. Two possible cases, Rotuman and Korean, are discussed in **de Haas (1988)** (see also **Sohn 1987**; **Rice 1995**; **Causley 1999a**). Coalescence of /e+o/ to [ø] is also described in Obolo (**Faraclas 1982**).

2.4 Glide formation

In Ganda (cf. (3) above) and quite a few other languages, both front and back V_1's are subject to glide formation. It is also quite common, however, to find that only back round vowels glide and that front V_1's trigger a different resolution strategy, most commonly elision. This is the case for example in Xhosa (see §2.5 below) and Chumburung (**Snider 1985**). Though they are seemingly less common, there are also languages (e.g. Polish; **Rubach 2000**) in which only front vowels glide.

A second point of variation involves the height of V_1. Generally, if a language has glide formation at all, high V_1's will undergo the process (**Rosenthall 1994, 1997**; **Casali 1995**). In some languages (e.g. Ebira; **Adive 1989**), *only* high V_1's glide. In quite a large number of other languages, however, mid V_1's also glide.[6] One such case, Chicano Spanish, is illustrated in the examples below (from Baković 2007, with phonemic forms substituted for orthographic ones):

(15)	a.	/mi ultima/	→	[mjultima]	'my last one (FEM)'
		/mi obɾa/	→	[mjoβɾa]	'my deed'
		/tu epoka/	→	[twepoka]	'your time'
		/tu alma/	→	[twalma]	'your soul'
	b.	/me urxe/	→	[mjurxe]	'it is urgent to me'
		/porke a beses/	→	[porkjaβeses]	'because sometimes'
		/komo eba/	→	[komweβa]	'like Eva'
		/lo abla/	→	[lwaβla]	'speaks it'

Further variation exists as well. In some languages, glide formation does not apply to sequences in which V_1 and V_2 share the same frontness and roundness. In Gichode (Casali 1998: 168–169), for example, glide formation of a round vowel occurs only before non-round vowels, e.g. /u+i/ > [wi] but /ʊ+o/ > [o] (*[wo]). (Contrast this with realization of /u+o/ as [wo] in Ganda, as in (3) above.) Glide formation is also blocked in some languages (e.g. Ganda; Clements 1986) following certain consonants.[7] Typically, both sorts of restrictions can be attributed to constraints that are effective quite generally in the language (e.g. languages that fail to glide /u/ or /o/ before a round vowel typically lack [Cw] before round vowels in general).

Finally, some languages impose less stringent restrictions on glide formation when V_1 occurs in absolute word-initial position. In Ganda, for example, only high V_1's generally glide in word-internal /CV_1–V_2/sequences. Word-initially, however, mid and even low V_1's undergo glide formation (in this case without compensatory lengthening), as in the examples below (Clements 1986: 75, n. 1):[8]

(16)	/o-a-gula/	→	[wagula]	'you (SG) bought'
	/a-a-gula/	→	[jagula]	'he/she bought'
	/e-a-laba/	→	[jalaba]	'it (cl. 9) saw'

Rather similar patterns are reported in Nyarwanda (Kimenyi 1979).

Notwithstanding the considerable variation that exists in its patterning, there is one very significant respect in which the behavior of glide formation is surprisingly regular across languages. Quite consistently, (non-word-initial) sequences in which V_1 and V_2 are identical regularly fail to undergo glide formation. We can illustrate this restriction with additional examples from Ganda (Clements 1986):

(17)	/mi-iko/	→	[mi:ko]	*[mji:ko]	'trowels'
	/lu-uji/	→	[lu:ji]	*[lwu:ji]	'side'

Moreover, sequences such as /o+u/ and /e+i/, in which V_1 and V_2 are both front or both round and V_1 is *lower* than V_2, rarely if ever trigger glide formation, but are resolved instead by vowel elision or coalescence (Casali 1995, 1998: 172, n. 5).

Exceptions to these generalizations clearly arise in absolute word-initial position in some languages, as in the Ganda example in (16) above. I am not aware of any languages that consistently violate these restrictions word-internally, however.

2.5 Multiple hiatus resolution strategies in the same language

It is quite common to find two or more different hiatus resolution processes at work in the same language. In some such cases, different processes are operative in different morphosyntactic contexts. In Axininca Campa (Baković 2003) and Washo (Midtlyng 2005), for example, hiatus is resolved by vowel elision at a prefix—stem boundary but by epenthesis at a stem—suffix boundary. In Lugisu (Brown 1970), a sequence /a+i/ is resolved by coalescence (to [e]) across a word boundary, but by eliding /a/ word-internally.

There are also many cases, however, in which multiple strategies apply in exactly the same morphosyntactic context, targeting different vowel sequences. Especially common are cases (see Casali 1998: 83–84) in which vowel elision occurs along with glide formation, coalescence, or both. Languages with both vowel elision and glide formation (but not coalescence) include Ganda, Etsako (Elimelech 1976), Igede (Bergman 1968), and Chicano Spanish (Baković 2007). Languages with coalescence and vowel elision (but not glide formation) include Afar (Bliese 1981) and Owon Afa (Awobuluyi 1972). Particularly intricate patterns are found in a considerable number of languages (32 cases are listed in Casali 1998: 83–84) that manifest all three processes. One such language is Xhosa (McLaren 1955; Aoki 1974), whose hiatus resolution alternations conform to the following generalizations:

(18) *Hiatus resolution in Xhosa*

a. Where V_1 is non-high and V_2 is high, the outcome is a [−high] version of V_2.

b. A round V_1 undergoes glide formation before a following non-round vowel.9

c. Elsewhere, V_1 elision applies.

The overall pattern corresponding to these generalizations is shown below in **Table 61.1**, where coalescent realizations are underlined and those involving glide formation are italicized. Note that in the case of the input /o+i/, *both* coalescence and glide formation apply.

		V_2				
		i	e	a	o	u
	i	i	e	a	o	u
	e	e̲	e	a	o	o̲
V_1	a	e̲	e	a	o	o̲
	o	*w̲e̲*	*we*	*wa*	o	o̲
	u	*wi*	*we*	*wa*	o	u

Table 61.1 Glide formation, coalescence, and vowel elision (in Xhosa)

Examples illustrating some of these realizations in Xhosa (**Aoki 1974**) are shown below:

(19) /esisu-ini/[10] → [esiswini] 'stomach (LOC)'
/ni-oʤa/ → [noʤa] 'you roast'
/ndi-akha/ → [ndakha] 'I build'
/ni-enza/ → [nenza] 'you make'
/wa-ejele/ → [wejele] 'he fell in'
/aɓa-oni/ → [aɓoni] 'wrong doers'
/aɓa-akhi/ → [aɓakhi] 'builders'
/wa-inkosi/ → [wenkosi] 'of the chiefs'
/wa-umfazi/ → [womfazi] 'of the woman'
/esilo-ini/ → [esilweni] 'animal'

The descriptive summary of the Xhosa patterns in (18) illustrates something that is quite typical of languages that combine vowel elision with glide formation and/or coalescence, which is that it is generally possible to regard vowel elision as a kind of default process. That is, the simplest way of describing the relevant generalizations is often to specify the conditions under which glide formation and/or coalescence apply, with a statement that vowel elision applies elsewhere.

All three processes – vowel elision, glide formation, and coalescence – can occur either with or without compensatory lengthening, depending on the language (see CHAPTER 64: COMPENSATORY LENGTHENING). Typically, if compensatory lengthening applies with one process it will apply with the others as well. Thus, Ganda shows compensatory lengthening with both vowel elision and glide formation, while Xhosa does not show compensatory lengthening with either of these, nor with coalescence. It also appears generally true that languages (e.g. Ganda) with contrastive vowel length manifest compensatory lengthening while those with no phonemic length do not, but it remains to be seen how universal this correlation is.

3 Theoretical treatments and issues

3.1 Early generative phonology

Many analyses of hiatus resolution patterns in particular languages (e.g. **Brown 1970**; **Aoki 1974**; **Phelps 1975, 1979**; **Elimelech 1976**; **Halle 1978**; **Shaw 1980**; **Snider 1985**) were carried out within early generative phonological frameworks conforming roughly to the model proposed in **Chomsky and Halle (1968)** or its offshoots. In such models, hiatus resolution processes are due to the operation of language-specific phonological rules. To account for the Xhosa hiatus resolution patterns in (19), for example, **Aoki (1974**: 239) posits three ordered rules of Vowel Lowering, Glide Formation, and Vowel Deletion, which (with minor notational adjustments) are essentially those in (20):

(20) a. *Vowel Lowering*

$$V \rightarrow [-\text{high}] \;/\; \begin{bmatrix} V \\ -\text{high} \end{bmatrix} \_\_$$

b. *Glide Formation*

$$\begin{bmatrix} V \\ +\text{round} \end{bmatrix} \rightarrow [-\text{vocalic}] \;/\; \_\_\; V$$

c. *Vowel Deletion*

$$V \rightarrow \varnothing \;/\; \_\_\; V$$

Derivations illustrating the operation of these rules are shown below (**Aoki 1974**: 40):[11]

(21)

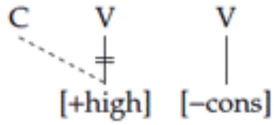
Underlying Form	/wa-umfazi/	/esisu-ini/	/esilo-ini/
Vowel Lowering	wa-omfazi	—	esilo-eni
Glide Formation	—	esisw-ini	esilw-eni
Vowel Deletion	w-omfazi	—	—
Output	[womfazi]	[esiswini]	[esilweni]

The formal apparatus of early generative phonology frequently offered multiple possibilities for analyzing a given pattern. For example, in contrast to Aoki's analysis of Xhosa coalescence using separate vowel lowering and elision rules, other researchers (e.g. **Phelps 1975, 1979**; **Halle 1978**) treated very similar patterns in other languages using a type of rule, known as a *transformational* rule, which is capable of simultaneously affecting (and, in the case of coalescence, merging the features of) two different segments. Perhaps not surprisingly, much of the literature on hiatus resolution patterns of this period focused on issues of rule formulation and the related question of when the rules for two potentially related processes might appropriately be collapsed into a single rule. Aoki's paper, which provides extensive arguments against a transformational rule analysis of coalescence (on the grounds that it is arbitrary and unrevealing and that it leads to an unnecessary increase in the complexity and power of the theory), is itself an interesting case in point. Other relevant work includes **Brown (1970)**, **Harms (1973)**, **Hyman (1973)**, **Shaw (1980)**, **Snider (1985)**, and an extended debate (**Chomsky and Halle 1968**; **Phelps 1975**, 1979; **Halle 1978**) over some particularly intricate patterns in Kasem.

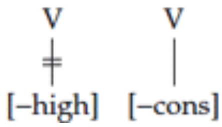
3.2 Autosegmental and non-linear generative phonology

The late 1970s and 1980s saw the development of alternative and greatly elaborated *autosegmental* or *non-linear* conceptions of phonological structure in which some or all phonological features are assumed to occur on separate structural tiers (see CHAPTER 14: AUTOSEGMENTS). A number of studies of hiatus resolution phenomena (e.g. **Katamba 1985**; **Clements 1986**; **Pulleyblank 1986**, 1988; **Sohn 1987**; **de Haas 1988**; **Snider 1989**) were carried out using such models. We will look at one representative (and influential) case in some detail, **Clements' (1986)** treatment of glide formation and elision in Ganda (see (3) above). Clements' analysis employs the rules in (22).[12]

(22) a. *Glide Formation*

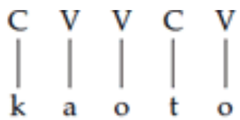


b. *Non-high Vowel Deletion*

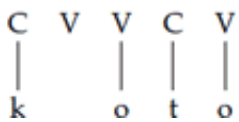


An appealing feature of Clements' analysis is that it provides a very straightforward account of the compensatory lengthening that accompanies both elision and glide formation in Ganda. Both rules in (22) have the effect of delinking a V element from its associated vowel features. This is illustrated below for the case of vowel elision. (23a) shows the underlying form corresponding to /ka-oto/ ([ko:to]) 'small fireplace' within Clements' model, while (23b) shows the representation that results when this form is subjected to rule (22b) (Non-high Vowel Deletion), which delinks /a / from its associated V element, in conjunction with a further (universal) convention that is assumed to delete unassociated segments (in this case the delinked /a/).

(23) a.

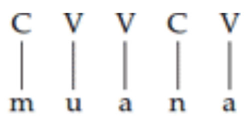


b.

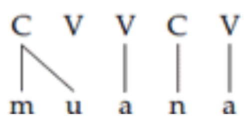


The parallel forms in (24) illustrate the application of the Glide Formation rule (22a). (24a) shows the underlying form of /mu-ana/ ([mwaːna]) 'child', and (24b) shows the result of applying Glide Formation to this form.

(24) a.



b.



Following the application of these rules, the forms in (23b) and (24b) both contain an unassociated V element. Clements assumes that there is a universal *Linking Convention* that has the effect of automatically reassociating such an unassociated V element to an accessible vowel segment (subject to a general prohibition on crossing of association lines). Applied to the representations in (23b) and (24b), this convention yields the representations in (25a) and (b), respectively.

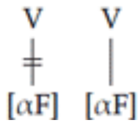
(25) a.

b.

In these surface representations, V_2 emerges as a long vowel, since it is linked to two V elements (see CHAPTER 54: THE SKELETON). This account encodes quite directly the intuition that compensatory lengthening involves the transfer of duration from one segment to another.

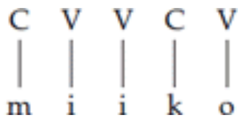
There is a further wrinkle to the analysis. As noted in §2.4 above, glide formation does not apply in Ganda to the sequences /i+i/ and /u+u/, in which V_1 and V_2 are identical. To prevent the Glide Formation rule (22a) from applying to these sequences, Clements posits an additional rule of Twin Vowel Deletion that is ordered before Glide Formation and functions to remove sequences of identical high vowels as possible inputs to the latter:

(26) *Twin Vowel Deletion*



This rule is applicable to words like /mi-iko/ [miːko] 'trowels', whose underlying form is shown in (27):

(27)



Application of Twin Vowel Deletion, along with the universal convention requiring deletion of unassociated segments and the Linking Convention that accomplishes reassociation of a free V element, will convert this to (28).

(28)

Since the form in (28) does not meet the structural description for Glide Formation to apply, the analysis correctly predicts [mi:ko] and not *[mji:ko] as the surface form. While the analysis derives the correct forms, however, the need to posit the language-specific rule (26) implies that immunity of sequences of identical vowels from glide formation is an idiosyncratic characteristic of the language. As noted in §2.4, such sequences appear to be regularly exempt from glide formation in other languages as well, suggesting that something more universal than a language-specific rule (26) is at work. (Potentially, this presents an interesting challenge not only for autosegmental models like Clements' but for other approaches as well.)

A strong interest of many autosegmental theories is the specification of phonological features. Much research has been done in particular on the possibility of accounting for certain phonological patterns based on the assumption that only one value of a feature is phonologically specified (see CHAPTER 7: FEATURE SPECIFICATION AND UNDERSPECIFICATION). Underspecification models of this type have potential implications for the analysis of vowel coalescence. One of the analytical questions that arises in connection with coalescence is what determines which features of the two merged vowels are preserved in the output. An interesting general answer to this question, pursued in a study by **de Haas (1988)** (see also **Sohn 1987** and **Snider 1989**), is that the underlyingly specified features from both vowels are preserved in the output. Preservation of all specified features of both vowels under coalescence would presumably be impossible in cases where the two vowels have opposite values of some feature, since this would lead to a surface vowel simultaneously specified as both [+F] and [−F] for some feature [F]. Following previous work in radical underspecification theory, de Haas assumes that only one value of each feature is underlyingly specified. Consider in this regard the symmetric coalescence of /o/ and /a/ to [ɔ] in Attic Greek, as in the relevant forms in (4) above, repeated here as (29).

(29)	/tiːma-omen/	→	[tiː.mɔ̂ː.men]	(/ao/ > [ɔː])	'honor (1PL PRES IND)'
	/ajdo-a/	→	[aj.dɔ̂ː]	(/oa/ > [ɔː])	'shame (ACC SG)'

In de Haas's underspecification analysis, /a/ is specified only as [+low] and [+back] at the point where coalescence applies, while /o/ is specified only as [+round]. Combining all three feature values yields a [+low], [+back], [+round] vowel, which in de Haas's analysis is equivalent to [ɔ].

Many autosegmental treatments of hiatus resolution processes were also concerned with the relationship between hiatus resolution and syllable structure and attempted to establish a formal connection between the two. In the model of **de Haas (1988)**, for example, (symmetric) coalescence is contingent on prior resyllabification of two adjacent vowels into a single syllable. Other autosegmental analyses that attempted to connect hiatus resolution to syllabification include **Katamba (1985)**, **Pulleyblank (1986)**, **Walli-Sagey (1986)**, **Schane (1987)**, and **Sohn (1987)**.

3.3 Optimality Theory

Analyses of hiatus resolution patterns within Optimality Theory (OT) date from the early years of the paradigm and include, among other studies, **Rosenthall (1994, 1997)**, **Casali (1995**, 1997, 1998), **Orie and Pulleyblank (1998)**, **Senturia (1998)**, **Causley (1999a, 1999b)**, and **Baković (2003, 2007)**. Though they differ somewhat in detail, most such analyses share the following general components:

(i) Some constraint (which must be highly ranked) that militates against heterosyllabic adjacent vowel sequences. There is some controversy (discussed below) over the exact identity of this constraint. For now, we will simply label it "NoHiatus."

(ii) Constraints that are violated by various hiatus resolution possibilities. Generally, vowel elision is assumed to violate a constraint Max, which requires underlying segments to be represented in surface forms. Epenthesis is assumed to violate a constraint Dep against insertion of material (as well as relevant markedness constraints against the features of the inserted consonant – see below). Diphthong formation violates a constraint NoDiph against diphthongs. Glide formation violates, minimally, a markedness constraint, here labeled *CG, against consonant + glide sequences.[13] Coalescence violates a constraint Uniformity, which prohibits merger of two underlyingly distinct segments into a single segment in the output.

Given these assumptions, hiatus resolution is forced whenever NoHiatus is ranked sufficiently high. At a rough first approximation, the particular form of hiatus resolution that occurs is determined by the constraint that is ranked lowest. For example, epenthesis is predicted to occur if the constraint Dep is outranked by the remaining constraints, as illustrated in (30), using a hypothetical input /ku abo/.

(30)

/ku abo/	NoHiatus	Max	NoDiph	*CG	Uniformity	Dep
a. .ku.a.bo.	*!					
b. .kua.bo.			*!			
c. .ka.bo.		*!				
d. .kwa.bo.				*!		
e. .ko.bo.					*!	
☞ f. .ku.ʔa.bo.						*

The simplified analysis sketched above would need to be significantly elaborated to account for the intricate patterns and interactions found in many languages.[14] It does, however, illustrate one important general feature of OT analyses, which is that all phonological processes occur in response to some markedness constraint(s). In this case, the primary markedness constraint is the constraint labeled 'NoHiatus' in (30). One of the issues that has been debated is the exact nature of this constraint. In what follows, we will look briefly at this question and several other important issues that arise within OT approaches to hiatus resolution.

3.3.1 What drives hiatus resolution?

Many descriptions and analyses of vowel hiatus resolution processes (e.g. **Brown 1970**; **Mtenje 1980**; **Shaw 1980**; **Katamba 1985**; **Pulleyblank 1986**; **Walli-Sagey 1986**; **Sohn 1987**; **de Haas 1988**; **Wiltshire 1992**; **Balogné Bérces 2006**) have suggested that such processes are motivated by factors related to canonical syllable structure, and in particular the need to avoid onsetless syllables (see **chapter 33**: syllable-internal structure and **chapter 55**: onsets). In OT, this notion has often been formalized by high ranking of a constraint Onset that requires syllables to have onsets, thus disallowing heterosyllabic V.V sequences which would arise in contexts where hiatus is maintained.

An alternative view is that hiatus resolution derives from an avoidance of vowel sequences, and not a requirement that all syllables have onsets. Such a view is made plausible by the observation that vowel hiatus seemingly involves unique phonetic difficulties not found with word-initial onsetless syllables. At least two kinds of difficulty have been cited. First, mutual co-articulatory interaction in a sequence of adjacent vowels tends to perturb the quality of each vowel, potentially making accurate identification of vowel qualities more difficult (**Borroff 2003**). A different explanation is proposed by **de Haas (1988)**, who sees the problem as a kind of "sonority clash" or "bad syllable contact" (see **chapter 49**: sonority and **chapter 21**: vowel height). The adjacent heterosyllabic vowels have (roughly) equal sonority, whereas the preferred transition between syllables should involve a sonority trough. Under the widespread assumption that constraints exist in response to particular phonetic challenges, these considerations lend support to the view that there should be some phonological constraint that specifically excludes hiatus.

Several studies have raised novel arguments that hiatus resolution cannot always be attributed to Onset. **Orie and Pulleyblank (1998)** argue that attributing hiatus resolution to Onset in Yoruba misses important generalizations about the conditions that govern the distribution of different hiatus resolution strategies across different contexts. They adopt instead a constraint NoHiatus, which is violated by vowels in hiatus but not by onsetless syllables in general. **Borroff (2003, 2007)** presents data from a number of languages in which the same hiatus resolution patterns found with clear /VV/ sequences apply to /VˀV/ sequences as well. In Chickasaw (**Borroff 2007**: 57, citing **Ulrich 1993**), for example, /VV/ hiatus is resolved by glide epenthesis, as shown in (31a). Interestingly, the same process applies to /VˀV/, as in (31b).

(31) a. /tof-to-a/ → [toftowa] 'to spit more than once'
b. /boʔ-a/ → [boʔw-a] 'to be beaten'

On the assumption that an intervocalic [ʔ] should suffice to satisfy ONSET, the fact that the same glide epenthesis process applies even when an intervocalic [ʔ] is present argues that something other than ONSET is responsible for hiatus resolution in this case. **Borroff (2003)** argues for a constraint VCV-COORD, motivated with reference to phonetic facts involving the sequencing of vowel gestures, which in essence requires that a consonantal target appear between two different vowels.[15]

Though the constraint is equivalent for most purposes to NOHIATUS, it is (in contrast to ONSET) crucially not satisfied by an intervocalic glottal stop, which lacks an (oral) gestural target. An alternative analysis (**Borroff 2007**) is to assume that a prevocalic glottal stop does not in fact satisfy ONSET. In either case, patterns such as these raise interesting challenges for familiar assumptions about hiatus resolution and its motivations.

3.3.2 Directionality in vowel elision

Any analysis of vowel elision in hiatus contexts must account for the choice of vowel, V_1 or V_2, that is elided. In rule-based models, the deleted vowel is typically specified directly in the form of the elision rule. For example, both the linear deletion rule (20c) and the autosegmental deletion rule (22b) given above stipulate deletion of the *first* of two adjacent vowels. In contrast, an account within Optimality Theory must assume that elision of V_1 or V_2 in a given context will violate different constraints, whose relative ranking determines which outcome occurs. The problem then becomes to identify the relevant constraints. The possible rankings of these constraints should also suffice to generate the V_1 or V_2 elision cases that are attested cross-linguistically, without predicting patterns that are unattested. Arguably, the relevant generalizations to be accounted for are at least approximately as summarized in (12) above.

A possible account of these generalizations is outlined in **Casali (1997)**. The explanation assumes that at a prefix—root juncture or a boundary between two content words, V_2 is protected by a constraint MAXMI or MAXWI, demanding, respectively, preservation of morpheme- and word-initial vowels. In addition, the analysis continues to assume a generic MAX constraint that is violated by deletion of a segment in *any* context. The analysis also assumes a constraint MAXLEX requiring preservation of segments in roots and in content words. Crucially, there are no analogous MAX constraints that specifically target word- or morpheme-*final* position, or affixes or function words.

A consequence of these assumptions is that in some contexts the constraint violations incurred by elision of V_1 will be a subset of those incurred by V_2 elision. At a prefix—root boundary, for example, elision of V_2 violates MAXMI (since V_2 is the root-initial segment), MAXLEX, and (ordinary) MAX, while elision of V_1 violates only the latter (assuming we are dealing with a minimally CV prefix, so that V_1 is not morpheme-initial).[16] Since the constraint violations incurred by V_1 elision in this context are a subset of those arising with V_2 elision, eliding V_2 in this context should, all else being equal, be more costly than eliding V_1. Thus, only V_1 elision is ordinarily expected in this context. This is illustrated below, using a hypothetical CV prefix and VCV root. Note that there is no ranking of the constraints under which the second candidate, with V_2 elision, is optimal.

(32)

/CV_1-V_2CV/	MAXMI	MAXLEX	MAX
☞ a. CV_2CV			*
b. CV_1CV	*!	*	*

Similarly, only V_1 elision is predicted when underlying vowels abut at the boundary between two content words. In this case, both V_1 elision and V_2 elision violate MAXLEX and general MAX; the two possibilities thus tie on these constraints. However, since V_2 elision violates MAXWI while V_1 elision does not, the former outcome is less optimal. This is illustrated below for a sequence of two hypothetical VCV content words.

(33)

/VCV_1 V_2CV/	MAXWI	MAXLEX	MAX
☞ a. VC V_2CV		*	*
b. VCV_1 CV	*!	*	*

In other contexts, elision of either vowel is predicted to be possible. For example, at a root—suffix boundary V_2 elision violates MAXMI but not MAXLEX. Thus, V_2 elision is possible if MAXLEX outranks MAXMI, as shown below using a hypothetical VCV root and VC suffix:

(34) /VCV$_1$-V$_2$C/	MaxLex	MaxMI	Max
a. VCV$_2$C	*!		*
☞ b. VCV$_1$C		*	*

V_1 elision, which violates MaxLex but not MaxMI, is predicted under the opposite ranking:

(35) /VCV$_1$-V$_2$C/	MaxMI	MaxLex	Max
☞ a. VCV$_2$C		*	*
b. VCV$_1$C	*!		*

For roughly analogous reasons, both V_1 elision and V_2 elision are predicted possibilities at the boundary between a content word and a following function word; in this context V_1 elision violates MaxLex but not MaxWI, while V_2 elision violates only the latter.

Note that this model encodes no general context-independent preference for elision of V_1; the overall statistical predominance of V_1 elision noted above arises indirectly from the fact that V_1 elision is predicted in a wider range of contexts. An alternative interpretation of the observed typology might suppose that there is a general context-independent preference for preservation of V_2, expressible as some constraint(s), and that this can be overridden in cases where V_1 occurs in a prominent position (and hence falls under the protection of some positional faithfulness constraint). The view that hiatus patterns reveal a general context-independent preference for preservation of V_2 is expressed by **Lamontagne and Rosenthall (1996)** (see also **Alderete 2003**), who refer to this effect as the *persistence of* V_2.

Finding evidence to distinguish the two accounts is not easy. There is one context, however, in which the two views potentially make different predictions: where underlying vowels come together morpheme-internally, for example due to the optional deletion of an intervening consonant. While the **Casali (1997)** model offers no clear predictions in such cases, a model assuming general persistence of V_2 should predict, all else being equal, that V_1 must elide. A number of languages do show vowel elision in such cases, and in at least some of them, this prediction is not borne out. Yoruba (**Orie and Pulleyblank 1998**; **Pulleyblank 1998**) and Igbo (**Emenanjo 1972**) both elide V_2, not V_1, in such cases. Though it might be premature to rule out the possible influence of other factors in these cases, these patterns at least appear to challenge the Persistence of V_2 view, especially since both languages normally show V_1 elision in other contexts (which could be attributed to constraints favoring preservation of initial segments).

3.3.3 Epenthetic consonants and markedness

As noted in §2.1 above, only certain consonants are widely observed to function epenthetically as hiatus interrupters. An adequate phonological theory should explain why this is so. Within OT, the problem of explaining the range of possible epenthetic consonants is closely tied to the question of *markedness* (see **chapter 4**: markedness; **chapter 12**: coronals; **chapter 22**: consonantal place of articulation). Since epenthetic consonants, by definition, are not present underlyingly, their featural content is not affected by faithfulness constraints requiring preservation of phonological material. Consequently, the epenthetic consonant used to resolve hiatus in a given language should be the consonant that is optimal with respect to relevant markedness constraints alone, as these are ranked in the language. The predicted typological range of possible epenthetic consonants should thus follow from the set of universal markedness constraints posited, together with any restrictions (assumed in some models) on their possible rankings.

We can illustrate the basic principles at issue with reference to markedness constraints on place of articulation (POA), which have received much attention in the recent literature. OT models have generally assumed markedness constraints targeting each major POA feature, e.g. the constraints *Lab, *Cor, *Dors, and *Glot, which ban, respectively, labial, coronal, dorsal (e.g. velar), and glottal consonants. All else being equal, the particular epenthetic consonant employed in a language is predicted to have the POA of whichever POA constraint is ranked lowest, e.g. a glottal consonant is expected if *Glot is lowest-ranked.

In a theory in which the possible ranking of these POA constraints varies freely across languages, we should expect that any POA could function epenthetically in some language. However, some phonologists have assumed that certain places of articulation are universally more marked than others. For example, **de Lacy (2006)** assumes the fixed scale in (36), where ">" means "is more marked than."

(36) dorsal > labial > coronal > glottal

It would be straightforward enough to translate this scale into a universally fixed ranking (i.e. one which is stipulated to hold in all languages as part of Universal Grammar) of POA constraints, as in (37).

(37) *Dors >> *Lab >> *Cor >> *Glot

Fixed rankings of this sort, with some disagreement over details, have played a role in a number of OT analyses (see for example **Lombardi 2002**). In place of such a fixed hierarchy, however, **de Lacy (2006**: 2) adopts a different technical implementation of the same general idea, specifically the set of freely rankable POA markedness constraints in (38):

(38)
a. *{Dors} — Assign a violation for each [dorsal] feature.
b. *{Dors,Lab} — Assign a violation for each [dorsal] and each [labial] feature.
c. *{Dors,Lab,Cor} — Assign a violation for each [dorsal], each [labial], and each [coronal] feature.
d. *{Dors,Lab,Cor,Glot} — Assign a violation for each [dorsal], each [labial], each [coronal], and each [glottal] feature.

In this system, a consonant at a POA further to the left on the scale in (36) will always incur worse violations of these POA constraints than one further to the right. This is because the violations incurred by a POA further to the left are necessarily a superset of those incurred by a POA further to the right, regardless of how these constraints are ranked, as shown below (**de Lacy 2006**: 50):

(39)

	*{Dors}	*{Dors,Lab}	*{Dors,Lab,Cor}	*{Dors,Lab,Cor,Glot}
k	*	*	*	*
p		*	*	*
t			*	*
ʔ				*

(Crucially, there are no further POA constraints, e.g. *{Cor} or *{Cor,Glot}, targeting other individual places or place combinations.)

If a fixed place markedness hierarchy of this sort were the whole story, we would predict that epenthetic consonants would always be glottals, since an epenthetic glottal consonant is always least costly according to this constraint system. This prediction is too restrictive, as it does not account for various other possibilities (e.g. coronals or a homorganic semivowel) that are reported to exist (see §2.1 above).

De Lacy's solution assumes that there are additional markedness scales that refer to dimensions other than place, and that these interact with the place markedness hierarchy to produce the observed range of typological possibilities. For example, the possibility of epenthesizing a coronal stop [t], as in Axininca Campa, follows from the assumption of an additional set of markedness constraints (this time related not to place but to manner of articulation) against high-sonority consonants in onsets, along with the further (and controversial – see **Lombardi 2002**; **Uffman 2007**) assumption that glottal consonants [ʔ] and [h] are higher in sonority than all non-glottal consonants (see **chapter 49**: sonority). These assumptions motivate a constraint *___ Δ_σ/Glot prohibiting glottals in syllable margins (onsets or codas). In languages in which *___ Δ_σ/Glot is ranked above the relevant POA marked-ness constraints, glottals will be excluded as epenthetic hiatus interrupters, despite their (universal) optimality with respect to POA alone. With glottals ruled out, the predicted outcome (all else being equal) should be the POA that fares second best according to the constraint system (see (39)). This is coronal.[17] The predicted outcome is illustrated in (40), using a hypothetical input /ai/.

(40)

/ai/	*__ Δ_σ/ Glottal	*{Dors}	*{Dors,Lab}	*{Dors,Lab, Cor}	*{Dors,Lab, Cor,Glot}
a. aki		*	*	*	*
b. api			*	*	*
☞ c. ati				*	*
d. aʔi	*				*

Epenthetic homorganic semivowels (e.g. [w] following /u/, [j] following /i/) are predicted in de Lacy's theory in cases where further markedness constraints requiring consonants (including epenthetic ones) to agree in their place and manner features with adjacent vowels are highly ranked. Additional markedness constraints generate a few further predicted possibilities in languages in which they are highly ranked. In all, the model predicts the following restricted range of epenthetic consonants in hiatus contexts: [ʔ t h ɹ r w j]. De Lacy claims that this set corresponds to the attested range of possibilities.

While de Lacy's theory provides a detailed, plausible, and comprehensive OT account of consonant epenthesis, it is unlikely to be the last word on the subject. The topic of markedness (both with respect to epenthesis and other areas) has been an extremely complex and controversial one. Among other things, some phonologists (see **Hume 2003**; **Rice 2007**; **CHAPTER 12**: CORONALS; **CHAPTER 22**: CONSONANTAL PLACE OF ARTICULATION) have questioned the claim that glottal (or any other) place of articulation is universally unmarked, arguing that either dorsal or labial (as well as coronal) can also function as the unmarked place in some languages. If this is correct, it would suggest the possibility of epenthetic consonants such as [p] or [k] as well. It remains, perhaps, to be seen whether such cases exist. De Lacy discusses several reported cases, but argues that they are better analyzed in other terms (for example because putative epenthetic consonants in some such cases can be treated as present underlyingly).

At present, a clear understanding of the typology of consonant epenthesis is arguably somewhat clouded by lack of clear consensus on relevant empirical generalizations. Considerable disagreement exists over the interpretation of patterns in some individual languages, a famous example being the question of whether the "intrusive r" phenomenon found in some English dialects (e.g. the pronunciation of *saw it* as [sɔɹɪt] in some Eastern Massachusetts dialects, including my own) constitutes epenthesis (see **de Lacy 2006**, **Lombardi 2002**, and Uffman 2007 for discussion of this and other cases). Certain cross-linguistic generalizations have also been disputed. For example, while glottal stop is widely regarded as a frequent choice of hiatus interrupter, **Uffmann (2007)** proposes that glottal stops are not typically inserted primarily to avoid hiatus, but are generally used (German is cited as one example) to provide an onset in prosodically strong positions, e.g. word-initially or before a stressed vowel, where they function to create a maximized sonority contrast with the following vowel. (This account crucially assumes that glottal stops are the *lowest* sonority consonants, which is exactly the opposite of what de Lacy assumes.) Undoubtedly, there will be further debate over some of the relevant empirical generalizations, as well as their appropriate theoretical treatment.

3.4 The problem of gradience

An important distinction in most phonological theories is the distinction between *categorical* and *gradient* processes (see **CHAPTER 89**: GRADIENCE AND CATEGORICALITY IN PHONOLOGICAL THEORY). A categorical change involves a clear "either-or" shift in the presence of one or more segments or their features, as in a case where an underlying segment is removed completely (elision) or undergoes changes in the binary values of one or more features. Frequently, however, languages manifest gradient processes that involve changes in the *degree* of some feature, e.g. a phonemically oral vowel is slightly nasalized next to a nasal consonant but remains less nasal than phonemic nasal vowels in the same language. In hiatus contexts, a possible gradient change might involve the "near elision" of one of the adjacent vowels, e.g. a case where an underlying /V_1 V_2/ sequence is realized phonetically as V_2 (perhaps with lengthening) preceded by a short and variable remnant of V_1.

Hiatus resolution processes have most often been described and analyzed in terms that suggest categorical changes. However, two recent instrumental studies, **Baltazani (2006)** and **Zsiga (1993, 1997)**, have shown that hiatus resolution patterns (glide formation and/or vowel elision) that had previously been described as categorical in two languages, Modern Greek and Igbo, respectively, actually involve gradient and highly variable timing adjustments. For reasons of space, we will consider only the Igbo case here.

Sequences of adjacent vowels arise very commonly in Igbo in cases where a word ending in a vowel precedes a word beginning in a vowel, as in the phrases shown below (from **Zsiga 1997**; the diacritics mark [−ATR] vowels).

(41) /a̙sa̙to̙ a̙to̙/ 'three sevens'
/o̙ti̙ o̙zo̙/ 'another grub'
/ezi a̙to̙/ 'three loans'
/ede a̙to̙/ 'three coco-yams'

Three Igbo subjects in **Zsiga's (1993)** study each produced six repetitions of each of these and various similar phrases in which one of the eight Igbo vowels occurs word-finally before one of the words [a̙to̙] 'three' or [o̙zo̙] 'another'. (In all, each of the eight vowels was used in two utterances.)

Vowel formant measurements of the digitized recordings showed extreme variation, even for the same utterance produced by the same speaker, in the realization of the underlying vowel sequences. These ranged from tokens showing essentially no deletion or assimilation (i.e. in which both vowels clearly surface) to those showing complete loss of V_1 (i.e. with the output consisting entirely of a lengthened version of V_2). If all the observed outcomes were of one of these two types, this might suggest a categorical but optional rule eliding V_1 with compensatory lengthening of V_2 (or a rule of total assimilation of V_1 to V_2). Importantly, however, the results show a range of intermediate realizations as well, in which formant values near the beginning of the vocalic span show a quality intermediate between V_1 and V_2. This intermediate quality varies across repetitions of the same utterance from one that is more similar to V_1 to one that is more similar to V_2. Zsiga argues that such findings are not easily reconcilable with an analysis that treats hiatus resolution as optional but categorical, and that the process is better understood as an adjustment in the relative timing of V_1 and V_2. More specifically, achievement of the target articulatory gestures for V_2 varies from relatively late (allowing for a more or less normal manifestation of a preceding V_1) to relatively early (resulting in partially assimilated tokens) to virtually at the release of the preceding consonant (in which case V_1 is essentially gone). Seen from this perspective, superficial instances of categorical deletion in some of the tokens are better regarded as simply the extreme endpoint of a process that applies along a continuum.

Though specific proposals vary, it has been widely assumed that the familiar kinds of phonological rules and/or constraints standardly used in the analysis of categorical processes are not appropriate to the treatment of gradient sound changes. Zsiga analyzes gradient hiatus resolution in Igbo using the framework of articulatory phonology (**Browman and Goldstein 1990**), a model that is well suited to handling variable adjustments in the relative timing of gestures.

In addition to highlighting the importance of (and need for additional) explicit theoretical treatments of gradient changes in hiatus contexts, these studies raise an important empirical issue as well. Hiatus resolution in both Igbo and Modern Greek had been described in some previous studies as categorical. This raises the possibility (see **Zsiga 1997**: 265) that other hiatus resolution processes that have been described as categorical in the literature might turn out to be gradient upon closer examination. Studies such as Baltazani's and Zsiga's underscore the need for careful attention to the possibility of gradience in the context of descriptive phonological fieldwork.

4 Summary

Hiatus resolution patterns are extremely varied. This chapter has provided a brief and necessarily selective look at some of the variation that occurs in the behavior of particular hiatus resolution processes and in their co-occurrence and interaction.

The range of explanatory models that have arisen in connection with hiatus resolution phenomena is also very broad. We have looked at a sample of theoretical proposals from several time periods, including early generative treatments, autosegmental analyses, and several OT models. The central research questions have varied somewhat from model to model. Whereas rule formalism and related issues were a central concern in early generative analyses, autosegmental analyses used more elaborated phonological representations to suggest new solutions to problems such as compensatory lengthening, the featural output of coalescence, and the role of syllable structure in hiatus resolution. Issues that have arisen within OT include the primary markedness constraint that triggers hiatus resolution, the constraint rankings that determine which of two adjacent vowels elides, and the problem of accounting for the range of consonants that can function epenthetically as hiatus interrupters. Finally, we have looked briefly at an issue, gradient hiatus-related processes, which poses potentially important theoretical and empirical challenges for any approach.

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Notes

1 It is also common to find cases in which the second of two vowels becomes non-syllabic, e.g. /gene-i/ 'race (DAT SG)' > [ge.nej.] in Attic Greek (de Haas 1988: 126). Generally, such cases are potentially analyzable as diphthong formation. See Senturia (1998: 12–15) for examples and related discussion.

2 This is not the case in Attic for the pair /a e/: /a+e/ yields [ɛː], while /e+a/ yields [ea].

3 One topic that is not treated, for reasons of space, is the typology of diphthong formation. See **Schane (1987)**, **Sohn (1987)**, **Rosenthall (1994)**, and **Senturia (1998)** for some discussion.

4 In addition to the more common cases in which the elided vowel is one that occupies a particular position, there are also cases (see **Casali 1996, 1998**; **Causley 1999b**) in which the vowel targeted depends on the featural makeup of the two vowels.

5 The particular [ATR] value that is preserved under height coalescence shows a strong correlation with a language's vowel inventory structure; see **Casali (1998, 2003)** and **Causley (1999a)** for discussion.

6 In rare cases, e.g. Aghem (**Hyman 1979**), languages may glide the low vowel /a/ as well.

7 In some languages, glide formation following certain consonants triggers further changes, e.g. /siV/ and /ziV/ are realized as [ʃV] and [ʒV] respectively in Ebira (**Adive 1989**).

8 Intervocalic gliding of non-high vowels also occurs in some three-vowel sequences discussed by Clements, as in /te-a-a-gula/ 'he/she didn't buy', realized as [tejagula].

9 Aoki's description implies that glide formation should apply before round vowels as well, e.g. /u+o/ > [wo], but he gives

no examples of such realizations. In contrast, McLaren's data and explicit statements (1955: 10) strongly suggest that gliding of /u/, /o/ occurs only before non-round vowels. I follow McLaren's account here.

10 **Aoki (1974**: 238) displays the underlying forms of the first and last forms in (19) as /isisu-ini/ and /isilo-ini/, respectively, but describes the lowering of the word-initial vowel form /i/ to [e] as a morphosyntactic replacement, suggesting that initial /e/ is present underlyingly.

11 The derivations in (21) differ slightly from those shown in Aoki due to an apparent typo in his derivation of [esiswini] and a minor (and irrelevant) difference in choice of underlying forms (see note 10).

12 Glide Formation as formulated in (22a) does not account for the cases where non-high vowels glide word-initially in (16). Clements proposes an additional rule to account for these, which we will not treat here.

13 Under some analyses (e.g. Baković 2007), gliding of [−high] vowels will also incur violations of a constraint Ident[high], which prohibits changes to the feature [high], since the resulting semivowel [w]/[j] is assumed to be [+high].

14 For some proposed constraints relevant to compensatory lengthening which are not considered in this simplified analysis, see **Rosenthall (1997)**.

15 More precisely, the label Vcv-Coord is a shorthand for a conjoined alignment constraint (see **chapter 62**: constraint conjunction) Align(V_1, release, C_1, target) & Align(C_1, release, V_2, target), which is described in prose as a requirement to “align the release of the first vowel in a sequence of vowels with the achievement of the target of a consonant, and align the release of that same consonant with the achievement of the target of the second vowel of a sequence” (**Borroff 2003**: 11).

16 The full analysis in **Casali (1997)** actually predicts that V_2 elision should be possible at prefix—root boundaries in the special case of a V prefix, since V_1 is protected by MaxWI and an additional constraint MaxMS requiring preservation of monosegmental morphemes. We will ignore these complications here.

17 See **Lombardi (2002)** for a similar proposal.

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